BIOMASS ELECTRICITY GENERATION (USING COCONUT SHELL CHARCOAL) FOR TIGER PRAWN AQUACULTURE AT SARAWAK COASTAL AREA.

ABU TALIB B. GHAZALI

Universiti Malaysia Sarawak
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BORANG PENYERAHAN TESIS

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This project report attached here to, entitled **"Biomass Electricity Generation (Using Coconut Shell Charcoal) For The Tiger Prawn Aquaculture at Sarawak Coastal Area"** prepared and submitted by **ABU TALIB GHAZALI** as a partial fulfillment of the requirement for the degree of Bachelor of Engineering with Honours in Mechanical and Manufacturing System is hereby read and approved by:

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Marekan & Masni

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ABSTRACT

Tiger prawn also scientifically known as *penaeus esculentus sp.*, is one of the most famous cultivated shrimp. Today, the industry of aquaculture, especially tiger prawn is becoming profitable and expanding rapidly, including the coastal areas of Sarawak. The need of energy to power the industry also plays important role. By considering biomass energy sources available within the farm, such as processed coconut residue (coconut shell charcoal) or other sources, the need of abundant and cheaper energy fuel can possibly be fulfilled. Therefore, the study is exploring the potential of biomass energy sources – the coconut shell charcoal which might be useful as the future alternative energy sources. The study is designed to identify the quantity of energy usage on the tiger prawn aquaculture activities and the quantity of coconut shell charcoal can be produced within its surrounding area. As a result, these two factors can be used as guidance for the installation and development of biomass energy or electricity generation plant in the future.

ABSTRAK

Udang harimau, dikenali secara saintifiknya sebagai *penaeus esculentus sp.* merupakan udang peliharaan yang sangat terkenal. Pada masa sekarang, industri pertanian laut atau akuakultur, terutamanya penternakan udang harimau merupakan industri yang menguntungkan dan berkembang dengan pesat, termasuklah kawasan persisiran pantai Sarawak. Dalam memastikan kerancakan dan kemajuan penternakan udang harimau ini berterusan, kuasa atau tenaga elektrik memainkan peranan yang sangat penting. Dengan mengambil kira sumber-sumber tenaga yang ada di sekeliling tempat penternakan, seperti sisa buah kelapa yang telah diproses (seperti arang tempurung) dan juga sumber-sumber tenaga biojisim yang lain, keperluan untuk mendapatkan tenaga biojisim dalam kuantiti yang banyak dan murah mungkin dapat dipenuhi. Oleh kerana itu, kajian ini dijalankan untuk mengenalpasti potensi sumber tenaga biojisim – arang tempurung kelapa yang mungkin juga boleh digunakan sebagai tenaga alternatif pada masa hadapan. Kajian ini direka untuk mengenalpasti kuantiti penggunaan tenaga atau elektrik di kawasan penternakan udang harimau, dan kuantiti arang tempurung kelapa yang dapat dihasilkan di kawasan berdekatan. Hasilnya, kajian ini boleh digunakan sebagai panduan untuk membina dan membangunkan janakuasa berasaskan sumber tenaga biojisim atau bahanapi biojisim pada masa hadapan.

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(E)	Total length of operation, (hour)
E_{out}	Energy content or heat energy (kWh)
p	Coconut production per hectare in a year (per hectare)
q_{cs}	Quantity of coconut needed in one tonne of coconut shell charcoal production (per tonne or per kilogram)
Q_{in}	Equal to E_{out}, the energy content or heat energy (kWh)
w_{cc}	Weight of coconut shell charcoal (tonne or kilogram)
$W_{net,out}$	Energy or electricity generated (kWh)

GREEK LETTER

η_{boiler}	Boiler efficiency

CHAPTER 1

INTRODUCTION

1.1 Tiger Prawn Aquaculture Activity in Malaysia

Tiger prawn as shown in **Figure 1.1**, is scientifically known as *Penaeus esculentus*, which is an edible crustaceans similar to but larger than the shrimps. Its size is around 340mm in total length. It is generally brown in color with dark banding; their rostrum and antennae are also banded.

Figure 1.1 Tiger Prawn, *Penaeus esculentus* [CSIRO, 1997]

Nowadays, tiger prawn aquaculture becomes a popular industry in Malaysia, and this industry is rapidly growing lately. Began with the large-scale of shrimp aquaculture in 1930s, with depended entirely on the wild seed, their productivity was low. However, for the last few years this industry was grow rapidly [Takla, 1997]. With practicing more intensive approaches, modern aquaculture methods and the commitment of several companies resulted rapid growth of tiger prawn farms and their profitability. In 1987 production giant tiger prawn was 1,260 metric tons (mt), and it was almost five times of the 1986 production [Takla, 1997].

The growing of this industry continues, spurred by the governmental approval of 36 aquaculture projects between 1986 and 1988, tiger prawn production grew to 3,937 metric tones by 1993 [Takla, 1997]. According to Malaysian Department of Fisheries Director-General, Datuk Shahrom Abdul Majid, aquaculture production of tiger prawns is expected to expand to 220,000 metric tones by 2010 [*New Straits Times*, November 7, 1995].

Followed by the increase of tiger prawn farm areas, the energy consumption, especially electricity will also be increased. The electricity power is needed at the tiger prawn farms, especially for water pumps, air-conditions, lamps, electric motors and other equipments, which are the basic equipments in this industry. In conjunction to meet the energy requirement at the tiger prawn farms, besides from domestic electricity supply or solar energy, biomass energy is one of the highly potential energy which can be utilized.

Traditionally, in developing countries, biomass energy is used to produce heat for cooking, space heating and also can be a source of light. It is inefficient usage of energy where, there is only 5 – 15 % of the energy is actually utilized [Hall and House, 2001]. By using the new technology such as direct combustion, or gasification by converting it first into combustible gases; biomass energy can be implemented in large scale and have an economic value.

According to Hall and House [2001], biomass is the fourth largest sources of energy in the world which supplied about 13% (55 EJ/year; 25 million barrels of oil equivalent) of 1990 primary energy. By the year 2050, biomass could provide 38 % of world's direct fuel use, and 17% of the world's electricity.

Hall and House [2001] also stated that many developing countries such as Brazil already used biomass fuel such as pure bioethanol to almost 5 million of vehicles, where this biofuel is produced from sugarcane. In Zimbabwe, the production of 40 million liters of ethanol has been possible since 1983 and enables this country to tackle its energy problem. In China there are about 822 biogas biogas power stations or biogas electric power stations, with a total of 7,836 kW have been operated.

Not only in developing countries, a number of industrialized countries such as the United State of America (U.S.A) derived about 3% to 4% of its total energy from biomass (7.5 Mtoe, 3.2 EJ) with a biomass electric generating capacity of about 7,000 MW [Bioenergy Information

Network, 2001]. In Sweden 16% of its energy is from biomass [Hall and House, 2001].

The most important fact about the biomass energy is, its renewable characteristic. Renewable energy means any energy source that can be replenished continuously or within a moderate timeframe, as a result of natural energy flows. The so-called "renewable" include solar energy (heat and electricity), wind power, hydropower, and geothermal power.

1.3 Sources of Biomass Energy

Biomass for energy may be obtained from three main types of sources – forest residues, energy corps and agricultural residues. Another sources of biomass energy are aquatic plants, but it is less important. All these sources are converted into another useful form for heat and electricity generation.

1.3.1 Forest Residues

Forest, also known as natural vegetation can be either contributes logs or "merchantable bole" – that have commercial value; or forest harvested leftover or forest residues. Logs or wood in particular, is the oldest sources of energy and it still constitutes the most important sources in Less Developed Countries.

Normally logs are used for construction purposes such as to build house, bridge and trains railway; and forest or logging residues such as branches, stumps, roots, and including top are used to generate biomass energy. However, some forest production like mangrove forest is harvested for its charcoal – one of the most important biomass energy sources.

The use of wood (forest product, or forest residue) in the U.S.A is about 2.2 X 10^9 GJ per year in 1980 and will be doubled to 4.0 X 10^9 GJ per year in the year of 2000, [Lowenstein, 1985]. **Table 1.1** shows the use of wood compares with other biomass materials and total U.S. energy use in 1980 with that projected for 2000.

Table 1.1 Biomass Energy in the United State of America [Lowenstein, 1985]

Source of energy	**Quads (10^{15} Btu or 10^9 GJ/yrs)**	
	1980	**2000**
Wood	2.2	4
Agriculture residue	0.1	0.5
Municipal solid waste	0.2	1
U.S.A total energy use	75	95

1.3.2 Energy Corps

A second source of biomass energy is energy corps, the plants grown explicitly for the specific purpose of producing energy (electricity or liquid fuels). The most popular examples of energy corps are sugar cane, switch-grass, willow and poplar. There is many other energy corps that could be potentially used such as the stems or stalks of alfalfa, corn and sorghum. Energy corps can be converted to fuel by doing fermentation process. For example, sugar cane and sweet sorghum can directly fermented to produce ethanol.

Besides grown as biomass energy sources, energy corps species have a special characteristic those advantageous environment qualities such as erosion control, soil organic matter build-up and reduced fertilizer and pesticide requirements.

1.3.3 Agricultural Residues

Agricultural activities, besides as a sources of foodstuff to the world population, its residues also can be exploited to generate energy and fuels. Agricultural residues include plant parts such as corn fiber, dregs of sugar cane, rice strew and hull, nutshell, palm fiber and shell, and coconut shell; and animal (livestock or farm animal) waste such as wet dried waste [John, 1992].

For example palm fiber, palm shell, and coconut shell can be used in direct combustion to generate heat and electricity at power plants; and animal waste can be digested in biogas digester, to produce biogas (methane) – the biomass fuels.

Nearly every part of the world has a biomass resource. From forestry waste to agricultural residues, and from million acres of energy corps to thousands of manure (animal waste) lagoons, they are all biomass resource that can be tapped to make biofuels and can used to generate electric power. By using the present or modern conversion technologies, all these resources can be used to meet the future world energy consumption.

1.4 Coconut Shell Charcoal – Chosen Biomass Fuel Sources for The Study

Coconut is botanically known as *Cocos nucifera* L. and belongs to the natural order Arecaceae (Palmae), an important member of monocotyledons. It is one of the most important of all cultivated palms in the world and according to Thampan [1993]; this palm is growing in more than 80 countries of the tropical. It has a pan-tropical distribution, occurring in coastal areas between 20^0 North and 20^0 South of the equator [Persley, 1992].

In Malay community, coconut is often referred as the *'tree of life'* since almost every part is used to make item of value such as cooking oil, candies, copra cake, nata de coca, hut roof, midrib broom, mattress, rope, charcoal briquette, dye stuff, bottle brush and other products.

1.5.1 Combustion

Combustion or direct combustion is the most straightforward, simplest and cheapest method of biomass conversion. This process is as simple as just burn the biomass raw material to generate heat energy for space heating and cooking. For more complex process, with burning of biomass produces heat (as in any simple furnace) where this heat is captured by boiling water to generate steam. This steam will turn the turbines and drive the generators that will convert the energy to electricity [Bioenergy Information Network (BIN), 2001]. Normally air-dried wood is used in this process, and it has energy content of some 15 MJ kg $^{-1}$ [John, 1992].

1.5.2 Pyrolysis

Pyrolysis or carbonization is the process of heating the plant material in the absence of oxygen to give a variety of gaseous, liquid and solid fuels [John, 1992]. Wood starts to decomposition at 300^{0}C and will be stopped at 150^{0}C, and oils from this process can be extended as fuel. Another product is converting wood into charcoal that is used to generate heat energy for electricity generation.

1.5.3 Gasification

Gasification is the process where combustion releases gases. Solid biomass can be converted into a fuel gas in a gasifier such as shown in **Figure 1.3**. In